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SELECTION AND TREATMENT OF WATERS FOR SPRAYING PURPOSES WITH ESPECIAL REFERENCE TO SANTA CLARA VALLEY*

By E. R. deONG

The use of hard, alkaline, or saline waters in the preparation or dilution of sprays and dips has long been recognized as inadvisable, since such waters may seriously reduce the efficiency of the mixture or may produce chemical combinations dangerous to vegetation and animals: (1) by chemical reactions with insecticidal or fungicidal materials, which neutralize their efficiency or form dangerous compounds; for example, the use of alkaline or saline water with acid (standard) arsenate of lead may produce a soluble arsenical dangerous to foliage; (2) by physical reactions, such as the breaking of oil or cresol emulsions with hard water, which frees the chemicals held in suspension and destroys the value of the mixture. We now recognize such dangerous or neutralizing reactions when hard and perhaps alkaline waters are combined with petroleum or cresol emulsions, acid lead arsenate, fish-oil or whale-oil soap and nicotine sulphate.[1] The formation of a precipitate in combining lime-sulfur solution with hard water has also been noted. A further study of this subject may reveal other dangerous or undesirable combinations.

Defining Alkaline and Hard Waters.—Water containing considerable quantities of soluble sodium salts, including chlorids, sulphates, and carbonates, is classified as "alkaline." When calcium (lime) or magnesium is present in considerable proportion either in the bicarbonate or sulphate form, the water is termed "hard." The hardness of water is of two types, "temporary" and "permanent." The first is due to the presence of bicarbonate of calcium or magnesium held in solution in the water by an excess of carbonic acid. This type may be broken up by boiling, which frees the carbonic acid and throws the calcium out of the solution as carbonate. Permanent hardness is the condition resulting from the presence of sulphates or chlorids

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* The author wishes to acknowledge the valuable assistance received in this work from Mr. George P. Gray, Chief of the Division of Chemistry, State Department of Agriculture, and from the Division of Plant Nutrition, University of California.

[1] Marion Imes, Cattle Lice and How to Eradicate Them. U. S. D. A., Farmers' Bull. 909, p. 14, 1918.

of calcium and magnesium and of the carbonates still held in solution after boiling.[2] This cannot be overcome by heating. Both types can, however, be partially counteracted by the addition of caustic soda, lye, or other chemical water softeners. In this bulletin, no distinction is made between the various kinds of hardness, whether due to bicarbonte, sulphate or chlorid of calcium and magnesium, as their reaction with soap is somewhat similar. Neither is any distinction drawn between temporary and permanent hardness of water, the total hardness alone being estimated.

Plan of the Survey.—As waters may contain dangerous quantities of salts, a survey to discover something of the degree of hardness and the distribution of such waters was made during the summer of 1919 in the Santa Clara Valley, California, a typical horticultural region, supplied with moisture principally by ground water. Here the degree of hardness, as explained later, was found to vary from 4 to 92 per cent, while the hardness in the water of one supply company increased 11 per cent from the first of May until the middle of August. Complete yearly records have not been kept but we would expect that the concentration of salts in underground water would increase during a long continued, arid season, such as is common in California. Samples of water were collected from the entire valley and tested by means of a standard soap solution. A knowledge of the comparative quantity of salts present was thus obtained, but it was not possible to distinguish between the kinds of salts, as their action on soap is, in most instances, similar. A map of the surveyed region was made (see Fig. 1, page 304) giving the location of each well tested. Surveys of this nature, giving definite information about local water supplies, will enable the orchardist to choose spray materials suitable to his water supply. The manufacturer of insecticides will find this information of value in preparing and marketing his materials, and to the horticultural officer it will serve as a guide for his recommendations and will assist in explaining orchard troubles.

Determination of Hardness.—The soap-consuming or destroying power of a sample of water was measured by means of a standard soap solution, the same method of determination being used throughout so that the results are comparable. The soap solution used was prepared by Prof. P. L. Hibbard, of the Division of Plant Nutrition of the University of California, and contained approximately 70 parts of alcohol, 29 parts of water, and .4 per cent Ivory soap. The test is usually made by measuring out 50 c.c. of the sample of water

[2] Standard Methods for Examination of Waters and Sewage, ed. 2 (1912), American Public Health Association, p. 32.

into a stoppered bottle and adding measured quantities of the soap solution, with frequent agitations, until a stable lather is formed which remains permanent for two minutes. The samples examined were mostly hard, so that to avoid using large quantities of the standardized soap solution, 10 c.c. of the sample were diluted with 40 c.c. of distilled water. The soap solution was then added in small quantities, shaken vigorously after each addition until a permanent lather was secured over the entire surface of the water, with the bottle lying flat on its side. The number of cubic centimeters of soap solution thus used, multiplied by fifty (when 10 c.c. of the water sample were used) gives roughly the parts per million of calcium carbonate or equivalent salts. This process of calculation is not entirely accurate, but, since comparative results are wanted and not exact analyses, it serves the purpose of this investigation. If desired, a more accurate estimate of the degree of hardness can be obtained by checking the number of cubic centimeters of soap solution used with the tables found in standard works on water analysis.[3]

Summary of Water Tests.—A condensed record of all the tests made[4] is shown in Table 1. The column at the left indicates the relative degree of hardness as found in various sets of samples. For example, 4–5 includes all the samples which required from 4.0 to 5.0 cubic centimeters of soap to give a permanent lather. The column of percentages at the right of the table gives the proportion in which this degree of hardness was present in the total of all tests made.

TABLE 1

SUMMARY OF HARDNESS DETERMINATIONS OF SANTA CLARA VALLEY WATERS

Soap solution used Cubic centimeters	Proportion in amount of total tests Per cent
4–5	1.04
5–6	11.96
6–7	34.12
7–8	36.27
8–9	12.42
9–10	2.30
10 plus	1.89
	100.00

[3] *Op. cit.*, p. 33.

[4] Copies of the detailed reports of the tests made in the Santa Clara Valley are available at the office of the Director of Experiment Station, University of California, Berkeley, the Deciduous Fruit Station, Mountain View, California and the office of the County Horticultural Commissioner, San José. As an aid in identifying the samples, the name of the owner or resident of the property from which the sample was taken is given, together with the district in which it is located, and the name of the nearest road.

Assuming that six and less denote "soft" water, it will be seen that only 13 per cent of the total tests listed in Table 1 can be placed in this class. If those of a slight degree of hardness, viz., 6–7, are included, the total still falls below 50 per cent, leaving a remainder of 53.88 per cent of the waters classified as decidedly hard. It will be seen from the map that the districts containing the most uniformly soft waters are located at the extreme northerly and southerly ends, viz., Agnew and Gilroy. The slightly hard waters, with an occasional soft well, are quite evently distributed throughout

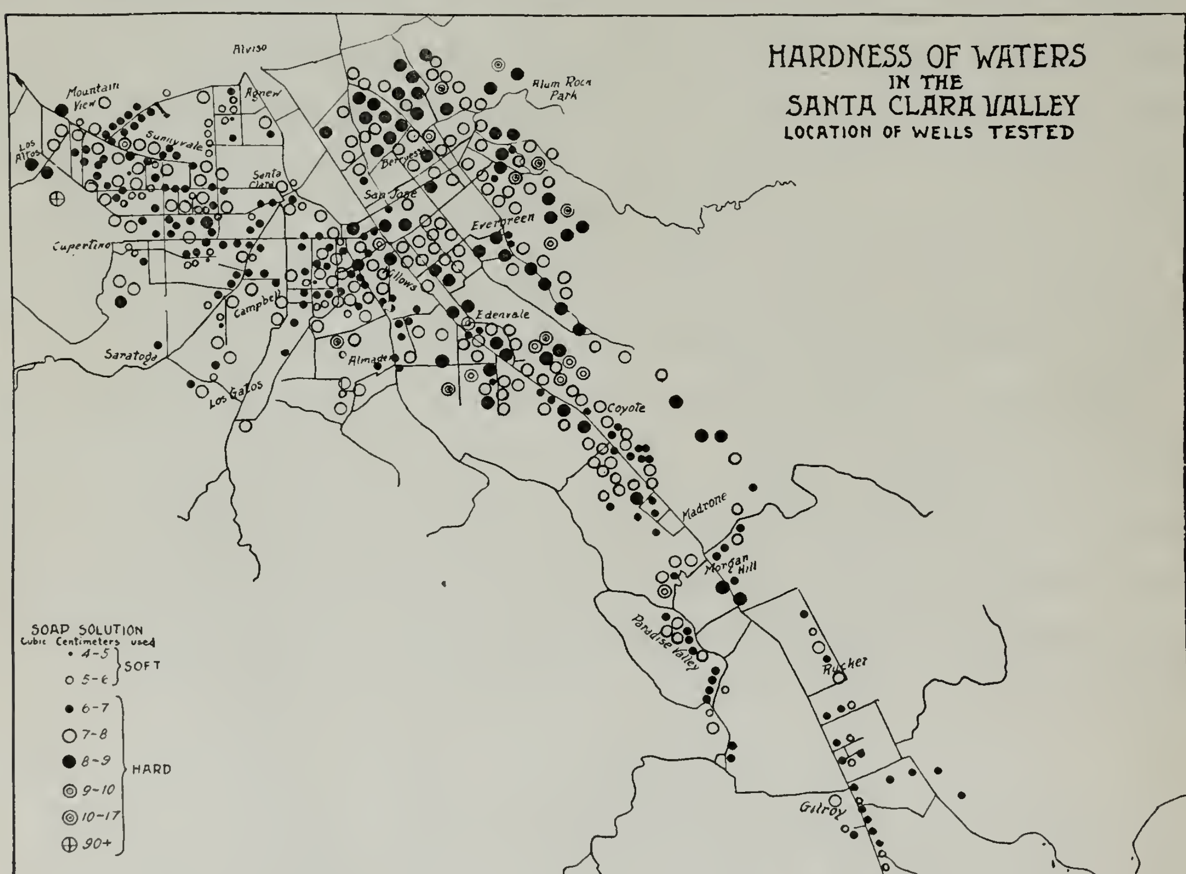

Fig. 1.—Map showing location and degree of hardness of waters tested.

the floor of the valley, but on approaching the foothills, the degree of hardness usually rises rapidly, as shown in the districts of Berryessa, Evergreen, Morgan Hill, Almaden, and Los Altos. Considering the valley as a whole, it must be rated as a region of hard waters with occasional exceptions. In a locality where hard water is so thoroughly distributed, the use of oil emulsions, as commonly made, must be and is attended with considerable difficulty.

WATER SOFTENING

The removal of temporary hardness from water by boiling is too expensive to be applied in preparing sprays, hence we must depend on chemical water softeners to reduce both the temporary and permanent hardness to a point where the water is usable. Such chemicals

may have different functions in making oil emulsions, viz., (1) reacting with the salts in the water, thus reducing the soap-consuming power; (2) aiding in emulsifying the oil; (3) preventing the formation of insoluble calcium and magnesium soaps, as these soaps have a tendency to clog the spray nozzle.

The chemicals tested are arranged below in the order of their merit, with regard first, to economy and their value as water softeners.

Caustic Soda (NaOH) was found to be superior, particularly in very hard water, to all other chemicals experimented with for softening water, preliminary to emulsifying either crude oil or distillates. The caustic soda used was a commercial form, 95 per cent pure, selling then for sixteen cents a pound. A good grade of caustic soda is desirable, although the presence of a little carbonate of soda is not objectionable since the two forms precipitate different chemicals.

Soda Ash.—A brand of washing soda known as the "Wyandotte" is the common water softener used in Santa Clara Valley. This chemical removes the calcium carbonate in solution in the water but does not aid in emulsifying the oil as does caustic soda. Its value was less than that of caustic soda, especially in very hard water.

"Hydro Pura" and "Rain-Water Crystals" are two commercial water softeners used locally for laundry purposes. Analyses of samples by the Insecticidal[5] and Fungicidal Laboratory of the University of California showed them to be mixtures of sodium phosphate and sodium carbonate. They were about equal in value and ranked next to caustic soda. Their high cost, however, prevents their general use.

Lye of commerce is usually a mixture of caustic soda and carbonate of soda. This would seem to be a good combination, but in practice it was found inferior to caustic soda.

Sal Soda ($Na_2CO_3 \cdot 10H_2O$) is the crystallized and purified product from soda ash. Its behavior is similar to the crude article, soda ash.

Ammonia has also been found of value with some waters in the making of emulsions.

Use of Caustic Soda.—The value of caustic soda in softening waters whose degree of hardness ranged from 7.2 to 9.1 is shown in Table 2. The data given here may serve as a guide in determining the amount of soda to use per 100 gallons. For example, 1.6 pounds of caustic soda (costing 25 cents) per 100 gallons of water reduced by 40 per cent the amount of soap necessary to emulsify oil. Later it will be shown that from one to two pounds of caustic soda is sufficient to give a satisfactory emulsion with most waters of this degree of hardness.

[5] Now a part of the Division of Chemistry, State Department of Agriculture.

For many soft waters one half-pound to a pound of caustic soda per 100 gallons was sufficient.

TABLE 2

THE VALUE OF CAUSTIC SODA AS A WATER SOFTENER
(Amounts based on 100 gallons of spray mixture.)

Caustic soda		Reduction of soap consumption		Difference
Amount Pounds	Cost	Amount* Per cent	Cost	Loss or gain†
1.6	$0.256	40	$0.51	$0.26+
3.2	.51	54	.69	.18+
6.4	1.02	59	.75	.27—

* The amounts in this table were figured on a basis of eight pounds of soap per 100 gallons. Soap and soda valued at 16 cents a pound.

† The results from the use of caustic soda cannot be estimated alone by the reduction in soap consumption. Its value as an aid in emulsifying the oil is difficult to determine but must be considered.

OIL EMULSIONS AND HARD WATER

Petroleum oil is usually emulsified by the use of fish oil or laundry soap. It is a well known fact that the use of hard water in the household and laundry hinders the formation of lather. Similarly, hard water destroys oil emulsions. In both instances, the soluble soda and potash soaps, which are unaffected chemically by soft water, react with the calcium and magnesium salts in the hard water and form an insoluble soap or "curdle," as it is sometimes expressed. This insoluble soap is of no value in making emulsions or to increase the cleansing power of the laundry water and hence is a waste. Therefore, if a hard water is used in preparing or diluting an emulsion, the hardness must be removed by the use of a preliminary softening agent or by sufficient soap to produce the same result. A slight amount of alkali does not materially retard the action of soap, but if excessive quantities of sodium salts are present the formation of lather is checked.

Oil Emulsions Made with Different Types of Water.—The variations found in the degree of water hardness require a corresponding adjustment in the formulas for making oil sprays. Trials were made with a number of waters, to secure a satisfactory emulsion with a minimum amount of soap and water softener. A summary of these trials is shown in Table 3.

The amounts of water softener and soap given are averages of trials which have produced satisfactory emulsions with a number of waters with the degrees of hardness given in columns 1 and 6. These figures indicate the amounts of soap and softener required for making emulsions with water of a similar type, or the softener alone if prepared emulsions are used which are not adapted to hard water.

TABLE 3

SUMMARY OF MODIFIED FORMULAS FOR MAKING OIL EMULSIONS WITH WATERS OF VARYING DEGREES OF HARDNESS

(Amounts based on 100 gallons of spray mixture.)

Crude Oil					Distillate Oil				
Caustic Soda			Soda Ash		Caustic Soda			Soda Ash	
Degree of Hardness	Amount of Caustic Soda	Amount of Soap	Amount of Soda Ash	Amount of Soap	Degree of Hardness	Amount of Caustic Soda	Amount of Soap	Amount of Soda Ash	Amount of Soap
c. c.	pounds	pounds	pounds	pounds	c. c.	pounds	pounds	pounds	pounds
4-4.9	0.5	2.47	....	....	5-5.9	0.75	5.5	3.0	5.5
5-5.9	0.66	4.83	1.5	6.0	6-6.9	0.5+*	5.0	2.0	5.0
6-6.9	0.50	6.33	2.0	5.0	9-9.9	1.5	5.0	....	....
7-7.9	0.8	6.83	2.2	7.8					
8-8.9	1.0	7.0	....	....					
9-9.9	1.+	7.0	....	....					

*Only one test was made with distillate on account of a scarcity of this type of water. The figures given are the exact readings while the other amounts in the table are averages. This amount of variation is common in working with large series of similar types.

Some variation, from the amounts given, will of course be necessary for different types of water and oil. The data given are simply the results from experiments where satisfactory emulsions were secured, and hence may be taken as a basis from which to work. It should be remembered, however, that changes in the type of oil, water, or softener used mean a new experiment, and should be considered as such.

TABLE 4

SUMMARY OF THE COMPARATIVE EMULSIFYING POWERS OF LAUNDRY AND FISH-OIL SOAPS

(Amounts based on 100 gallons of spray mixture.)

Soap used	Amount of soap Pounds	Amount of soda ash Pounds	Kerosene Gallons	Quality of emulsion
Ivory Soap	2	4	10	Satisfactory
Crystal White	3	4	10	Satisfactory
White Flyer	3	4	10	Satisfactory
Ammonia Borax	3	4	10	Satisfactory
Octagon Soap Powder	3	4	10	Unsatisfactory
Borax Aid	3	4	10	Unsatisfactory
Pearline	3	4	10	Unsatisfactory
Light House Cleanser	3	4	10	Very unsatisfactory
Fish oil*	5	3	10	Satisfactory

* A semi-liquid soap containing about 25 per cent more moisture than a hard soap.

A common formula for making crude oil emulsion with moderately hard waters has been 12 to 18 pounds of hard soap or 3 to 4½ gallons of liquid soap per 200 gallon tank, with soda ash as the water softener. In such a case, it would be well to try substituting caustic soda for soda ash and to use 25 to 50 per cent less soap. Where prepared emulsions are used with soda ash in hard waters a change in the type of water softener might be found desirable. In making a change from a well established custom, it is always well, however, to try the experiment in a small way before mixing large quantities.

How to Use the Tables.—To locate the nearest water that has been tested, consult the map, then note the degree of hardness given. If no tests have been made near the water which is to be used, or if from any cause conditions seem to be different, then a simple test for determining the hardness may be made as described on page 312, "Home Testing of Waters." The numbers indicating the degree of hardness as given on the map may be interpreted as follows:

4 to 4.9—very soft
5 to 5.9—moderately soft
6 to 6.9—slightly hard
7 to 7.9—hard
8 to 8.9—very hard
9 to 9.9—extremely hard

For very hard waters, caustic soda will probably be found the most satisfactory as a water softener; the amount to be used may be determined from Table 3. This table will also act as a guide to the amount of soap necessary. To illustrate: If the waters in the vicinity of the one to be used have a "degree of hardness" of 7.5 to 8.5, the district is apparently one of hard water. Referring to Table 3 for a suitable formula, it will be noted that the waters which have this degree of hardness require about one pound of caustic soda as a water softener and about seven pounds of hard soap to make a satisfactory crude oil emulsion. Make an experiment with a small amount of the water and oil to be used, in the proportions suggested in the table, and if a satisfactory emulsion results proceed on a larger scale. Before making emulsions or diluting the commercial preparations (which are not compatible with caustics), wash out any lime-sulfur solution or Bordeaux mixture that may be in the tank. Fill the latter two-thirds full of water, add the water softener, and allow it to dissolve, then add the dissolved soap and finally the oil. The oil should be added slowly with the agitator running.

THE RELATION BETWEEN ARSENICAL INJURY AND ALKALINE AND HARD WATERS

It has been shown in recent years that the soluble salts commonly occurring in waters (notably sodium chlorid, carbonate, and sulphate) if present in more than very small quantities, may exert a solvent action on acid lead arsenate. Headden[6] states that "he considers it unsafe to use alkali water as a carrier for lead arsenate" and cites experimental data where sodium sulphate and particularly sodium chlorid had acted as a solvent for lead arsenate. Haywood and McDonnell[7] report experiment data as follows:

(1) "Lead arsenate applied with spring water (containing 20 parts of chlorin per million) caused some injury to foliage."

(2) "When applied with distilled water, very slight injury occurred, noticeably less than when the spring water was used."

(3) "When applied with distilled water, to which 10 grains per gallon (171 parts per million) of sodium chlorid had been added, rather serious injury resulted. When distilled water containing 40 grains (684 parts per million) of sodium chlorid per gallon was used, the injury was very much increased, practically 50 per cent of the foliage being affected."

(4) "When applied with distilled water containing 10 grains of sodium carbonate per gallon (171 parts per million) injury was noticeable fourteen days after the first application, and seven days after the third application the trees were almost completely defoliated."

(5) "Applied with distilled water containing 10 and 40 grains (171 and 684 parts per million) of sodium sulphate per gallon, some injury resulted, but this was not so marked as that produced in the presence of sodium chlorid."

From the above data it will be seen that chlorin, in the form of sodium chlorid, is especially dangerous, even in such small amounts as twenty parts per million, and this element is very common in California waters, as will be shown later. The usual reaction between these two chemicals is the formation of a soluble arsenate and a complex lead salt. The latter may be disregarded but the sodium arsenate goes into solution readily in atmospheric moisture. This soluble

[6] Wm. P. Headden, Arsenical Poisoning of Fruit Trees, Colo. Agr. Exp. Sta. Bull. 131, p. 22, 1908.

[7] J. K. Haywood and C. C. McDonnell, Lead Arsenate, U. S. D. A., Bur. Chem. Bull. 131, pp. 46–49, 1910.

arsenic is then absorbed by the plant and causes burning. All hard waters do not necessarily contain chlorin but may have excessive quantities as shown in the following samples, which were analyzed by the Division of Plant Nutrition, University of California, the results being given in Table 5.

TABLE 5

ANALYSES OF CALIFORNIA WATERS

Constituent	Parts per million 1 Very soft	2 Slightly hard	3 Very hard
Calcium (Ca)	40	50	25
Magnesium (Mg)	5	20	100
Sodium (Na)	32	52	384
Bicarbonate (HCO_3)	183	256	646
Sulphate (SO_4)	10	50	150
Chlorin (Cl)	*10*	*40*	*440*
Soap Hardness	84	281	425

HYPOTHETICAL COMBINATIONS OF ABOVE ANALYSES

Constituent	Parts per million 1 Very soft	2 Slightly hard	3 Very hard
Sodium Sulphate (Na_2SO_4)	15	74	221
Sodium Chlorid (NaCl)	33	66	726
Sodium Bicarbonate ($NaHCO_3$)	51	17	109
Calcium Bicarbonate ($Ca(HCO_3)_2$)	160	200	100
Magnesium Bicarbonate ($Mg(HCO_3)_2$)	30	120	600

The degree of hardness in the various samples, as established in this survey, is: No. 1, 4.9; No. 2, 6.7; No. 3, 14.0. It will be noted that the chlorin content of only the first one is less than twenty parts per million—the amount which was associated with arsenical injury in Haywood and McDonnells experiments. As already mentioned, one of the common forms in which chlorin occurs is sodium chlorid (common table salt), which is a characteristic component of saline rather than of hard waters. A study of the analyses of California waters, as recorded by the Division of Plant Nutrition, University of California, revealed the following condition.

If 20 parts of chlorin per million be taken as the standard and any amounts over that be considered as possibly dangerous to very susceptible foliage, then of 80 analyses which this laboratory has made of California waters, we have the following proportions:

14.8% of total samples—safe for use with acid arsenate of lead.
12.1% of total samples—possibly dangerous on tender foliage.
36.7% of total samples—very dangerous.
36.4% of total samples—extremely dangerous.

These samples cannot be considered as entirely typical, since there is usually some suspicion regarding a water before an analysis is requested. They do show, however, the presence of dangerous waters

Fig. 2.—Arsenical injury to pear foliage, associated with the use of acid arsenate of lead in hard water.

in practically every part of the State. When it is necessary, in the preparation of spray, to use waters that are at all hard or alkaline, the best plan is to substitute basic arsenate of lead for the acid type,

though the addition of milk of lime or a quantity of lime water will usually make these waters safe for use with acid arsenate of lead.

PRACTICAL APPLICATIONS

The use of hard waters in spray mixtures is a serious problem which may be met in different ways: (1) the partial softening of the water by means of chemicals; (2) location of a source of soft water within hauling distance of the orchard; (3) impounding of surface waters during the rainy season; (4) installing a water-softening plant; (5) use of insecticides or fungicides which will not form dangerous combinations or will not lose their efficiency when combined with hard water; (6) use of dusts where practical instead of liquid sprays.

(1) *Water softeners* (pp. 304–306) may be economically used at a cost of from twenty to fifty cents per hundred gallons. Caustic soda has given the best results in these experiments. The commercial water softeners ''Hydro-Pura'' and ''Rain-Water Crystals'' were only slightly inferior to caustic soda in efficiency, but were more expensive. Soda ash may be used in fairly soft waters, but was found to be much inferior to caustic soda for making emulsions with hard waters. These materials may be varied in refractory cases with the chance of finding a form particularly adapted to certain waters.

(2) *Home testing of waters* may aid in locating a well or spring within hauling distance of the orchard, making it possible to avoid the expense and annoyance of working with hard waters. For such work a cubic centimeter graduate is desirable but if not available then place the water to be tested in a two quart Mason jar, filling it just one-tenth full. Add accurately measured quantities, for example 5 cubic centimeters or one teaspoonful of any soap solution, fasten the top securely, and agitate for ten seconds. A lather should result which will last for two minutes. If a very heavy lather results, dilute the stock of soap solution or use a smaller quantity. If the lather disappears too quickly, add another teaspoonful of the original soap solution. By using uniform quantities of the waters to be tested and the same stock solution of soap, a fairly accurate comparison of waters may be made and any marked difference in the degree of hardness determined. If desired, standardized soap solutions for testing waters may be obtained from most chemical houses.

(3) *Surface water* arising from rainfall is usually softer than water from springs or wells. In certain localities, it may be possible to impound running water in small reservoirs and thus secure a supply much superior to underground supplies. In many places in Santa Clara Valley, water for street sprinkling purposes is pumped from

creeks and piped long distances. This supply is drawn upon by the orchardists, and it may be found to be softer than their well water. In the interior valleys the irrigation canals, fed by the large rivers, will often prove a source of decidedly soft water.

(4) *Water-softening* plants are now on the market with a capacity suitable to the needs of a private home. The cost of these plants will probably range from a few hundred dollars up. These plants handle two or three thousand gallons or more in twenty-four hours at a moderate cost for operation, the greatest expense being that of installation. When rightly equipped, these should be more satisfactory than attempting to soften water by the addition of strong chemicals. This method will give soft water for the laundry and bath as well as for all other purposes, a factor much to be appreciated in the home.

(5) *Insecticides and fungicides compatible with hard water.* In many instances, standard materials may be found which can be used with hard waters with little or no danger of neutralizing their efficiency or of forming dangerous compounds. Where this can be done, it offers the simplest solution of the problem. Examples: the use of basic arsenate of lead (approximately one-fourth arsenic oxide) instead of the standard or acid type (about one-third arsenic oxide); oil emulsions or miscible oils which are made especially for use in hard waters; arsenical dips in place of cresol emulsions (sheep dip) or oil emulsions made by means of soda of potash soaps.

(6) *Dusting materials instead of spray mixtures,* where practical, also offer a convenient means of avoiding the danger from hard water. Much has been said recently about the advantage of dusts over sprays in the economy of time and labor, but the advantage of avoiding the use of hard or alkaline waters has apparently been overlooked.

CONCLUSION AND SUMMARY

Hard water forms dangerous combinations with or destroys the efficiency of many forms of insecticides. Such waters are very common, especially in the western states. Their distribution and degree of hardness, however, is a matter of only approximate knowledge.

Danger from the use of hard water comes both from a lack of recognition of its existence and from the imperfect methods of overcoming the difficulty when known.

Softening hard waters by means of caustic soda or other water softeners is not completely successful in all cases, and hauling soft water from a distance in quantities sufficient for spray purposes is frequently impracticable. Surface waters are usually softer than

underground supplies, but storage of the former during rainy seasons is possible only in limited areas.

Water-softening plants may be installed at a cost of a few hundred dollars with a sufficient capacity for supplying a spraying outfit and also meeting the domestic needs of the home. Water so treated is much improved for baths, laundry, and toilet purposes.

The use of dusting materials, for certain cases, in place of liquid sprays, offers an advantage in that the user is independent of the type of water.

Insecticides, compatible with the soluble salts commonly found in waters, are desirable and may be a satisfactory solution of the difficulty in some instances.

Water containing chlorin at the rate of 20 parts per million or more has been reported as dangerous to use with acid arsenate of lead, a soluble form of arsenate being formed which may cause severe foliage injury. Basic arsenate of lead should be substituted for the acid type if used with very hard or alkaline waters.

California waters have an unusually high chlorin content, which may account for cases of arsenical injury that have occurred where acid arsenate of lead has been used.